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P185

November 9, 1956

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SUBJECT: Contract RD-94
Task Order No. 2

[redacted] 25X1

In accordance with Article 2 of the basic contract, there are forwarded herewith two (2) copies of the Monthly Progress Report for October, 1956 on Task Order No. 2 of RD-94. The report is dated November 7, 1956. This report is UNCLASSIFIED. An additional copy is being held in [redacted] 25X1 by the project engineer for the use of your personnel while at this location.

In connection with this monthly progress report, the following information is submitted:

Total expenditures to 9-30-56	$6,982
Outstanding commitments as of 9-30-56	None
Funds remaining as of 9-30-56	$53,334

ILLEGIB [redacted]

Very truly yours,

[redacted] 25X1

Assistant Manager
Government Contract Administration

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f-14606
Enclosures
cc: [redacted] 25X1

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Monthly Progress Report
October 1956

Task Order No. 2
Contract No. RD-94

Audio Noise Reduction Circuits

The object of this project is to develop a noise reduction circuit suitable for use in separating speech intelligence from a signal containing speech and noise when the speech intelligence is masked by the noise. The proposed method involves a principle which has been used successfully to improve the signal-to-noise ratio in music reproducing or transmission systems[1]. The system used for music contains bandpass filters which pass frequencies over a range of an octave or less. These filters are used at the input and output of a non-linear element. The output of the non-linear elements contain the fundamental, and also harmonics and subharmonics of the fundamental. However, since the pass band of the input and output bandpass filters is no greater than an octave, the harmonics and subharmonics are not transmitted by the system. The function of the non-linear element is to reject all noise signals below a given amplitude or threshold level. The threshold levels of the non-linear devices in each channel can be adjusted so that, in the absence of desired signal, the noise is rejected. When the desired signal is greater than the threshold level the non-linear elements allow the composite signal to pass. Thus, for passages of recorded music, when the music signal is below the noise level in a given frequency channel, the channel is inoperative, and its output is eliminated from the total output. Since the contribution of this channel to the total output would have been only noise, the overall noise level is reduced. When the music signal in a given channel is greater than the noise, the channel conducts and allows the composite signal to pass. Thus

1. H. F. Olson, "Electronics", Dec. 1947.

a channel conducts only when the desired signal is greater than the noise, and rejects when noise alone is present.

In order to apply this method of noise reduction to speech, when the wide band speech signal-to-noise ratio is very low, it is necessary to find frequency regions in which there are times when the speech amplitude is greater than the noise. Although the long time average spectrum of speech is continuous, and similar in shape to the spectrum of room noise,[2] the short time spectrum of various speech sounds contains regions of maximum energy called speech formants[3]. The assumption that this method of noise reduction could be utilized for speech was based upon the belief that it would be possible to find frequency regions in which the amplitude of the speech formants would be greater than the noise a substantial part of the time.

A study has been made to determine what bandwidths are required in order to obtain speech formant amplitudes above the noise when a wide band speech sample is just intelligible in noise. It is known that for noises with a continuous spectrum it is the noise components in the immediate frequency region of the masked tone which contribute to the masking[4]. When a very narrow band of noise is used to mask a pure tone, the masking increases as the bandwidth is increased until a certain bandwidth is reached. After this, as the bandwidth is increased, the amount of masking remains constant. This bandwidth at which the masking reaches a fixed value, is termed the critical bandwidth[5]. The critical bandwidth is a function of

2. H. Fletcher, "Speech and Hearing on Communication", Van Nostrand Co., Inc. NYC 1953 (see figures 61 and 70)

3. Op.cit. chap. 1

4. L. L. Beranek, "The Design of Speech Communication Systems", Proc. IRE, vol. 35, pp.882, Sept. 1947.

5. N. R. French and J. C. Steinberg, "Factors Governing the Intelligibility of Speech Sounds", Jour. Acoust. Soc. Amer. Vol.19, Jan. 1947 (see figure 7)

frequency. It is different when listening with one or two ears. The critical bandwidth for two ears as a function of frequency is shown in figure 1. Measurements have been made using filters which were both narrower and wider than the critical bandwidth. Both pure tones and speech mixed with continuous spectrum type noises have been studied. The spectra of the two types of noises used are in figure 2. The results of this study show that, for the narrowest permissible bands which can be used to pass speech formants, the number of times the speech formant amplitude in a given band exceeds the noise is small. Also, in these bands, the speech amplitude is never considerably greater than the noise. Since very narrow bandwidths are required to reduce the noise below the signal, the number of bands required to cover the speech spectrum is quite large. There is no satisfactory way of evaluating the effect upon speech intelligence of small contributions from many narrow bands without building a many channeled circuit and evaluating it by making articulation measurements. From the information available from studying a few channels throughout the speech spectrum it seems possible that some improvement in intelligibility can be effected, but this improvement may prove to be small.

During October the status of the project was reviewed with the cognizant technical representatives of the agency. In view of the fact that there is no convenient way to evaluate the contributions of a few narrow band channels to speech intelligibility, it has been decided that a complete multi-channel system must be built in order to determine the effectiveness of this method of improving speech intelligibility in noise. The system agreed upon would have a limited frequency range containing approximately 80 frequency channels in the frequency range from 700 to 3200 cps.

As a first step toward building this system a study of various non-linear devices has been initiated. The physical and electrical characteristics of several different non-linear elements are being studied[6,7]. High vacuum diodes, gas diodes[8], and crystal diodes

6. B. Chance et.al. Waveforms, McGraw Hill NYC 1949 Chapt.3.
7. Crystal Diodes, Sylvania Bulletin Ec36 Rev. 1-HO-555.
8. M. A. Townsend and W. A. Depp, "Cold Cathode Tubes for Transmission of Audio Signals", Bell Syst. Tech. J. Vol. 32 pp.1371-1391; Nov. 1953.

have been considered. It appears that, from the standpoint of circuit simplicity, the germanium diodes are the most desirable; however, because of their relatively low ratio of forward to reverse resistance the electrical characteristic of the germanium diodes are not as satisfactory as the high vacuum diodes. A test circuit has been built and both germanium and high vacuum diodes are being evaluated for application in the noise reduction circuit.

ESR:nan
November 7, 1956

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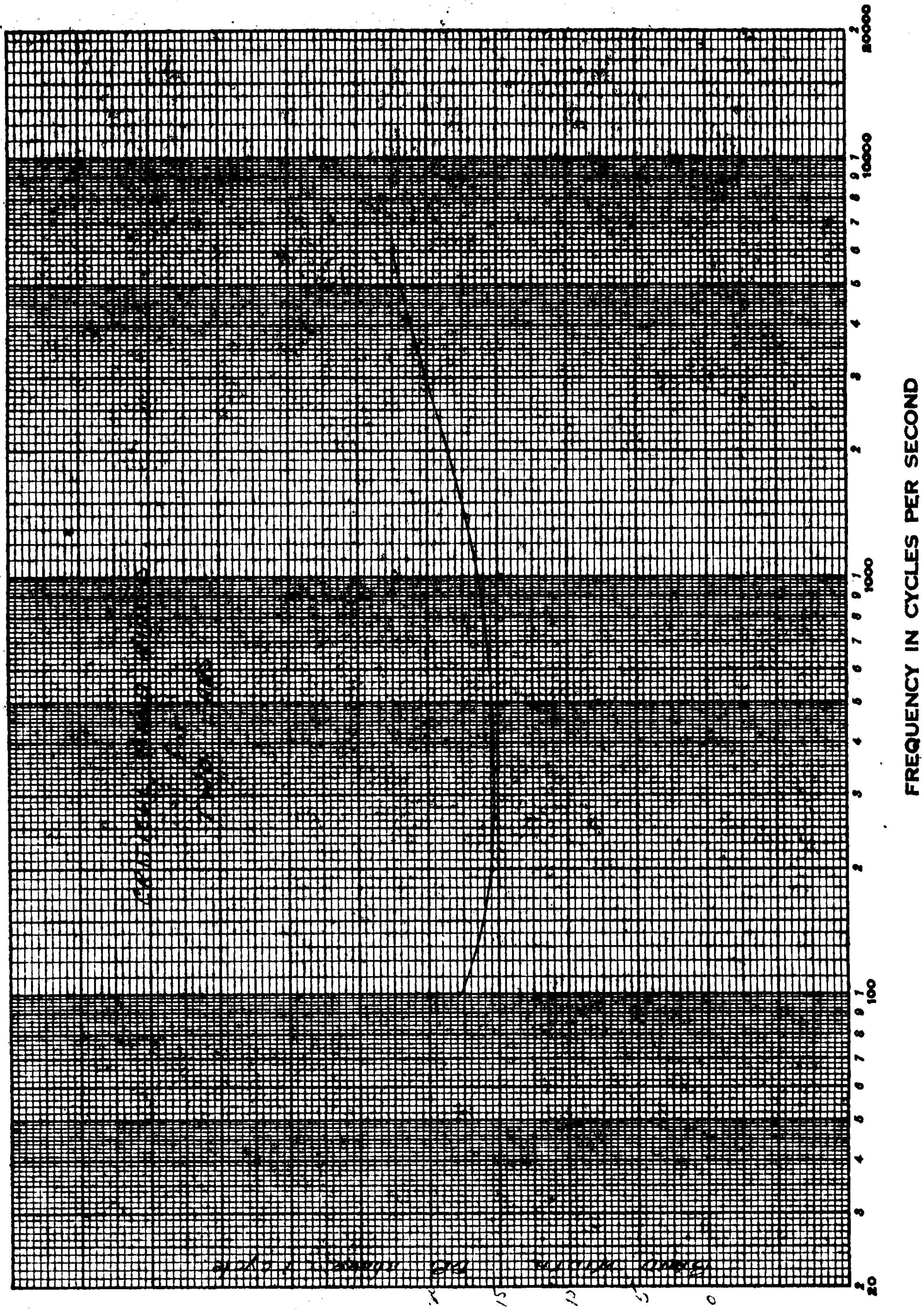

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FIG. 1

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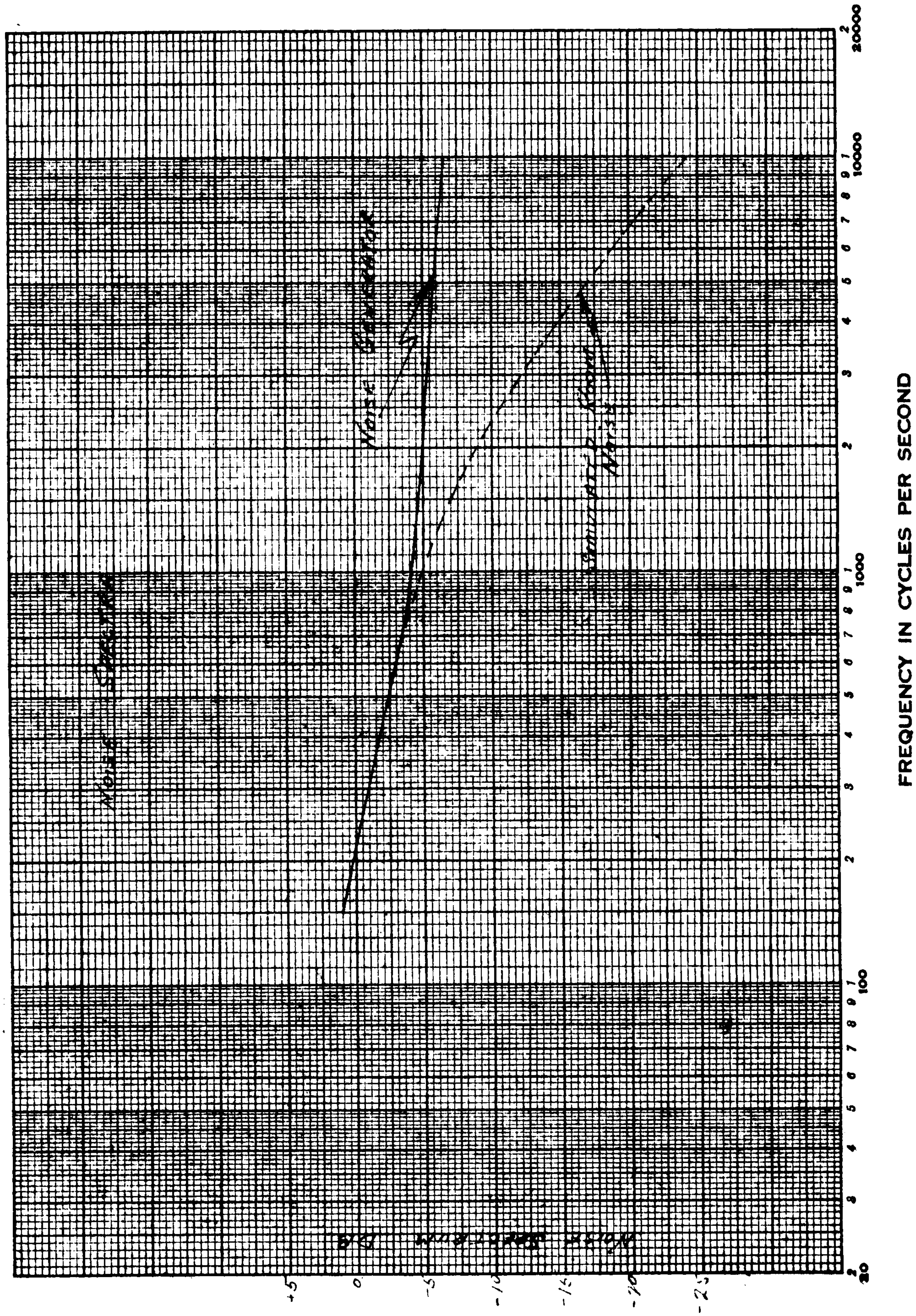

FIG. 2.

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